The Galileo Project
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Center for Astrophysics | Harvard & Smithsonian
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Interstellar meteors may have formed from extreme tidal disruption events

New paper proposes violent beginnings for high-velocity interstellar meteors such as IM1

HARVARD UNIVERSITY, CAMBRIDGE, MA — March 10, 2024 — The Galileo Project at Harvard University announced the publication of the latest paper to emerge from the IM1 meteor retrieval expedition off the coast of Papua New Guinea. Published in the peer-reviewed journal *Astronomy & Astrophysics*, the new paper describes a process by which extraordinary tidal forces shear layers of rocky planets into debris fields, flinging rocks at high speeds out of their original planetary systems.

The proposed mechanism of meteor formation, involving highly eccentric orbits of rocky planets around M-dwarf stars, may hold particular relevance to the unique characteristics of the interstellar meteor IM1, both in terms of its interstellar trajectory and speed, as well as the unique composition of the spherule materials found at the site of the meteor fireball.

“The high speed and inferred abundance of IM1, and the unique composition of the “BeLaU”-type composition, may be explained by tidal disruption of rocky exoplanets near dwarf stars,” said Harvard University astrophysicist Avi Loeb, who co-authored the paper with Smithsonian Astrophysical Observatory postdoctoral researcher Morgan MacLeod.

MacLeod adds, “It has been incredible to learn that sometimes, through interactions with their stars, chunks of planets can be launched into interstellar space directly toward us.” If this hypothesis is confirmed, the spherules collected from IM1 may in fact be pieces of an exoplanet that we can hold in our hands.

This interpretive paper follows on the heels of two published research notes[1,2] on the expedition and subsequent spherule analysis. An extensive paper on the expedition has been additionally submitted for peer review.[3] A preprint of the accepted paper may be found at https://arxiv.org/abs/2310.09399

[1] https://iopscience.iop.org/article/10.3847/2515-5172/ad2370
[2] https://www.hou.usra.edu/meetings/lpsc2024/pdf/2130.pdf
[3] https://arxiv.org/ftp/arxiv/papers/2401/2401.09882.pdf

About IM1

On January 8, 2014, US government satellites detected a fireball from a meteor, labeled IM1, that was moving faster than needed to escape from the solar system. The fireball location and likely interstellar origin of the object were confirmed in an official letter from the US Space Command to NASA, dated March 1, 2022. The meteor lightcurve showed three detonations 84 kilometers north of Papua New Guinea, spreading debris across a region of Pacific Ocean more than 11 kilometers wide.

Using DoD satellite data to localize the debris field, in June 2023, Loeb served as the Chief Scientist of an expedition coordinated by Rob McCallum of EYOS Expeditions to IM1's site in the Pacific Ocean. The expedition team conducted 26 runs with a magnetic sled through and around the DoD localization box and retrieved fragments that were subsequently analyzed in the laboratories of Harvard University professor Stein Jacobsen, and Dr. Roald Tagle at the Bruker Corporation in Berlin, Germany.

The expedition recovered 850 spherules (molten droplets) in the size range of 0.1-1.3 millimeters from the ocean floor near IM1's site, out of which about a tenth were found to have a unique chemical composition, never reported before for solar system materials. This unique chemical abundance pattern shows extremely high abundances (up to a thousand times higher than in the primordial solar-system material) of Beryllium, Lanthanum and Uranium, labeled as a never-seen-before "BeLaU"-type composition (see plot below). The loss of volatile elements is consistent with IM1's airburst in the Earth's atmosphere. Additionally, analysis of 60 elements from the periodic table indicates that these spherules are not coal ash, and did not likely originate from the crust of the Earth, the Moon or Mars.

Jacobsen affirmed the unique nature of the spherules found: "The "BeLaU"-type element abundance pattern is unprecedented in the scientific literature. It has the signature of extreme differentiation of a magma. This could have occurred on an exo-planet with an iron core, or some unknown and unsampled or lost place/planet in the solar system."

About Professor Avi Loeb

Avi Loeb is the head of the Galileo Project, founding director of Harvard University's Black Hole Initiative, director of the Institute for Theory and Computation at the Harvard-Smithsonian Center for Astrophysics, and the former chair of the astronomy department at Harvard University (2011-2020). He is the bestselling author of Extraterrestrial: The First Sign of Intelligent Life Beyond Earth and co-author of the textbook Life in the Cosmos. His latest book Interstellar was published in August 2023.

About the Galileo Project

The Galileo Project for the Systematic Scientific Search for Evidence of Extraterrestrial Technological Artifacts is a Harvard-hosted, cross-institutional research project founded in June of 2021 by Avi Loeb and Frank Laukien. The Galileo Project seeks to bring the search for evidence of Extraterrestrial Technological Civilizations (ETCs) into the mainstream of transparent, validated and systematic scientific research, searching for physical objects, artifacts, or traces, in addition to electromagnetic signals associated with extraterrestrial technological equipment.

About EYOS Expeditions LTD

EYOS Expeditions has been designing private expeditions since 2008, and the company's co-founders have spent decades designing groundbreaking itineraries. EYOS Expeditions holds several 'world's firsts,' routinely taking clients to destinations rarely or never before visited by private yachts. EYOS partner Rob McCallum has spent an entire career working in the undersea world. As a Partner at Deep Ocean Expeditions, he ran commercial expeditions to the RMS Titanic and the battleship Bismarck, and provided key logistical support to James Cameron's 'Deep Challenge' record-breaking dive to 35,000 feet in 2012. Previously he oversaw the construction of a super-yacht specifically designed around her three 1,000-meter rated submersibles.

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